

STS Off-Line Calibration

ORDA Systems Engineering

ABSTRACT:

These are the STS calibrations the technician performs to ensure system parameters are correct. These procedures include validating path loss calibrations and testing system calibration. These tests help a technician isolate problems and give the ability to view calibration results without waiting for an Automatic Calibration interval.

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| RF Test Switch | Error! Bookmark not defined. |

Tests

- STS
 - Off-Line Calibration uses System Test Software (STS) to perform all it's functions. This is the off-line maintenance software
- Test Names
 - Each test is independent, although some of the tests need data from other tests. Selecting one test will run all the tests needed for input data.
- Use
 - These tests will be used by the technician to:
 - isolate problems with the radar
 - verify system calibration
 - run specific calibrations on demand
 - These tests provide more information than available with the On-Line calibrations for use by technicians and engineers.
 - We can see all the parameters used in the equations, and the standard deviations for determining measured "goodness".
- Alarms
 - These Calibration routines use the same library calls as the on-line calibrations do, so they set and clear alarms when they're called.

- When you leave STS, the alarm status will depend on the last alarm status of any calibration test you ran. That is, if you entered STS with a calibration alarm (say Noise Temp Degraded), but after performing the Off-Line Calibration (Run Noise Temp for the example) the alarm clears, when you exit STS the alarm will be cleared (no more Noise Temp alarm).

Procedures

Sun Check

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- Purpose
 - Accurate position of the sun, noise of sun to calibrate antenna/radome gain
- Description
 - 2 Parts
 - Positional Accuracy
 - Raster scan across sun, parabolic curve fit for exact location
 - Antenna must be within .3° to find sun
 - Gain Check
 - Noise temp of sun, compared to sun flux
 - Setup
 - Parameters/Description
 - Algorithm

Short Pulse Reflectivity Error Estimate

[Top of the Document](#)

- Purpose
 - Estimates the errors in dBZ_0 related to power, noise, calibration linearity, and path in short pulse, the variables for dBZ_0 that change most pulse to pulse.
 - Provides troubleshooting guidance:
 - Power error – transmitter
 - Noise error – shared path, IFD, external interference
 - Shared Path – shared path, critical path
 - I_0 - Test Attenuator, non-linear response from LNA or Mixer/Preamplifier
 - dBZ_0 – bad R234, problem with another constant
- Description
 - Power Measurement
 - 8 second warm up
 - Measure power once per second for 10 seconds
 - Throw out min and max power measurement
 - Average the 8 power readings left
 - Calculate peak power
 - 5 iterations of:
 - Noise
 - Reflectivity and Linearity
 - Need I_0 from this
 - Take out worst of each measurement (Noise, I_0 (shared path))
 - Average the remaining 4 measurements
 - Compare to expected
 - Peak Power = 700Kw Transmitter
 - Noise = Adaptation Data
 - Shared Path = Adaptation Data
 - I_0 = Perfect slope and y-intercept
 - dBZ_0 = Calculated expected and show with measured and adaptation data
 - Show all data, give error estimate for each parameter except dBZ_0

- Setup

| | |
|---------------------------|---|
| Pulse Width | short |
| Antenna | Park |
| Clutter Filter | OFF |
| Point Clutter Suppression | OFF |
| Transmitter | Radiating as required |
| Injection Point | Front End |
| Matched Filter | Same as pulse width (automatic with SIGMET) |
| Receiver Protector | Normal |
| Noise Source | OFF |
| CW | ON as required |
| 4 Position Switch | As required |
| 7 Bit Test Attenuator | As required |
| Other Procedures | |

- Describe
- Parameters/Display

| Inputs | | | |
|------------------------|--------|-------|--|
| Name | Source | Units | Description |
| Noise _{Watts} | PMD | W | The previous noise value, used in smoothing the receiver noise value |
| Noise | A | | Short Pulse Noise |
| DBZ _{0 adapt} | A | dBZ | This is R234 in adaptation data |
| FE_Shared_Calc | | | From calibration shared memory |

| Outputs | | | |
|-----------------------------|------|-------|-------------|
| Calibration File | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |
| Display Data | | | |
| Name | Type | Units | Description |
| Noise Error | | dB | |
| Power Error | | dB | |
| Path Error | | dB | |
| All measured values | | | |
| All expected values | | | |
| All dBZ ₀ values | | dBZ | |

- Describe
- Algorithm
 - **Data Acquisition**
 - Measure Power Meter Zero, save as PowerZero
 - Radiate ON
 - Wait 8 seconds
 - For i = 1 to 10

- Get Power(i) /* Power Bite data, range from 0 to 255 */
- Wait 1 second /* Power Measurements only updated once a second from DAU */
- Radiate OFF
- Calculate Transmitter Peak Power from 10 samples

$$Tx_{ave_meas} = \left(\left(\frac{\sum_{n=1}^{n=10} Power(n)}{8} - Min(Power()) - Max(Power()) \right) - PowerZero \right) \times TR0$$

- $Tx_{Peak_meas} = (10Log(Tx_{ave_meas}) - DC - Tx_{PowMan} + 30)$
- Put Tx_{Peak} into Performance Data so it can be used with the following dBZ₀ calculation
- For i = 1 to 5
 - Run Noise check
 - Save Noise_{current}(i) (want noise in watts here)
 - Run Reflectivity and Linearity
 - Convert I₀(i) to milliwatts, dBZ₀(i) to mm⁶/m³, and FE_{Shared}(i) to ratio and save /* all these are changing from log by using 10^{value/10}. This is more accurate for averaging later*/
 - Wait 2 seconds (or so)
- PRI 5 (nominal PRF of 1013)

○ Data Calculations

$$Noise_{Meas} = 10 \log_{10} \left(\frac{\sum_{n=1}^{n=5} Noise_{current}(n) - Min(Noise_{current}()) - Max(Noise_{current}())}{3} \right)$$

/* in dBm */

$$FE_{meas} = 10 \log_{10} \left(\frac{\sum_{n=1}^{n=5} FE_Shared(n) - Min(FE_Shared()) - Max(FE_Shared())}{3} \right)$$

○ /* in dB */

$$I_{0_meas} = 10 \log_{10} \left(\frac{\sum_{n=1}^{n=5} I_0(n) - \min(I_0()) - \max(I_0())}{3} \right) \quad /* in dBm */$$

- $I_{0_exp} = \left(\frac{Noise_{meas} - 0}{1} \right) - FE_{meas}$ /* assumes perfect slope (1) and y-intercept (0)
- /*

$$dBZ_{0_meas} = 10 \log_{10} \left(\frac{\sum_{n=1}^{n=5} dBZ_0(n) - \min(dBZ_0()) - \max(dBZ_0())}{3} \right)$$

$$\text{dBZ}_{0_exp} = \left(\left(\frac{\text{Noise}_{exp} - 0}{1} \right) - FE_{SharedCalc} \right) + 10 \log(C) - (88.45 + PL_Tx) - Ant_Rx$$

$$DC = 10 \log_{10}(PRF * \tau) \text{ /* } \tau \text{ in seconds, should be approximately } -28.2\text{dB} \text{ */}$$

○ Error Estimates

- $Tx_{err} = 88.45 - Tx_{Peak_meas}$
- $Noise_{err} = Noise_Short - Noise_{meas}$ /* Noise_Short from Adaptation Data */
- $FE_{err} = FE_Shared_Calc - FE_{meas}$
- $I_{0_err} = I_{0_exp} - I_{0_meas}$
- $dBZ_{0_err} = dBZ_{0_exp} - dBZ_{0_meas}$ /* dBZ_{0_exp} is not what's in Adaptation Data. */
- Display the first 4 as errors, then display:
 - dBZ_{0_exp} dBZ_{0_meas} dBZ_{0_adapt}
 - Below and between, display:
 - dBZ_{0_err} ΔdBZ₀
 - This is so the technician can see the “perfect” dBZ₀ along with the value in AD
 - The error sum from the first 4 should add up to dBZ_{0_error} /* this is not displayed */
- If any error is over 1dB, highlight it somehow.
- *Explaining all this will take a little time, and fortunately for the programmer, the explanation will be in the Tech Manual*

Long Pulse Reflectivity Error Estimate

[Top of the Document](#)

- Purpose
 - Estimates the errors in DBZ₀ related to power, noise, calibration linearity, and path in long pulse, the variables for dBZ₀ that change most pulse to pulse.
 -
- Description
 - 5 iterations of:
 - Noise
 - Reflectivity and Linearity
 - Power Measurement
 - 8 second warm up
 - measure power once per second for 10 seconds
 - Throw out min and max power measurement
 - Average the 8 power readings left
 - Calculate peak power
 - Take out worst of each measurement (Noise, I₀ (shared path), Peak Power)
 - Average the remaining 4 measurements
 - Compare to expected's /* These are currently estimated, we'll put in actuals later */
 - Peak Power = 700Kw Transmitter
 - Noise = -82dBm, based on adaptation data
 - I₀ (shared path) = -112dBm /* we'll calculate this expected based on shared path and known values */
 - Show all data, give error estimate for each parameter
- Setup
 - Describe

- Parameters/Display

| Inputs | | | |
|------------------------|--------|-------|--|
| Name | Source | Units | Description |
| Noise _{Watts} | PMD | W | The previous noise value, used in smoothing the receiver noise value |
| | | | |

| Outputs | | | |
|------------------------------|------|-------|-------------|
| Calibration File | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |
| Performance/Maintenance Data | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| Display Data | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |

- Describe
- Algorithm
 - Data Acquisition**
 - For i = 1 to 5
 - Run Noise check
 - Save Noise_{current}(i) (want noise in watts here)
 - Wait 2 seconds
 - For i=1 to 5
 - Run Reflectivity and Linearity
 - Convert I₀(i) to milliwatts and FE_Shared(i) to ratio and save
 - Wait 2 seconds
 - PRI 1 (nominal PRF of 322)
 - Measure Power Meter Zero, save as PowerZero
 - Radiate ON
 - Wait 8 seconds
 - For i = 1 to 10
 - Get Power(i) /* Power Bite data, range from 0 to 255 */
 - Wait 1 second
 - Radiate OFF
 - Data Calculations**

- $$Noise_{Meas} = 10 \log_{10} \left(\frac{\left(\sum_{n=1}^{n=5} Noise_{current}(n) \right) - Min(Noise_{current}()) - Max(Noise_{current}())}{3} \right)$$
- $$I_{0_meas} = 10 \log_{10} \left(\frac{\left(\sum_{n=1}^{n=5} I_0(n) \right) - \min(I_0()) - \max(I_0())}{3} \right)$$
- $$FE_{meas} = \frac{\left(\sum_{n=1}^{n=5} FE_Shared(n) \right) - Min(FE_Shared()) - Max(FE_Shared())}{3}$$
- $$Tx_{ave_meas} = \left(\left(\frac{\left(\sum_{n=1}^{n=10} Power(n) \right) - Min(Power()) - Max(Power())}{8} \right) - PowerZero \right) \times TR09$$
- $DC = 10 \log_{10}(PRF * \tau)$ /* τ in seconds, should be approximately -28.2dB */
 - $Tx_{Pk_meas} = 10 \log_{10}(Tx_{ave_meas}) - DC - PL_{Tx} + 30$
- **Error Estimates**
 - $Tx_{err} = 88.45 - Tx_{Pk_meas}$
 - $Noise_{err} = Noise_Long - Noise_{meas}$ /* Noise_Long from Adaptation Data */
 - $FE_{err} = FE_Shared_Calc - 10 \log_{10}(FE_{meas})$ /* FE_{meas} in ratio */
 - $I_{0_err} = I_{0_exp} - 10 \log_{10}(I_{0_meas})$

Full Linearity

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- Purpose
 - Uses the test attenuator and both injection points to map the entire receiver transfer curve.
 - Calculates MDS, Dynamic Range, and DBZ₀
 - This test should show degradations in the receiver, and give the technician a good idea of where to start looking for problems.
 - This test uses some alternate means to determine some basic system characteristics to help verify system consistency
- Description
 - Run library routine for Full Linearity
 - Calculate MDS, DYN Range, and dBZ₀
 - Display receiver transfer curve graphically
 - Display measured and calculated data
- Setup

- Describe
- Parameters/Display

| Inputs | | | |
|------------------------|--------|-------|--|
| Name | Source | Units | Description |
| Noise _{Watts} | PMD | W | The previous noise value, used in smoothing the receiver noise value |
| | | | |

| Outputs | | | |
|------------------------------|------|-------|-------------|
| Calibration File | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |
| Performance/Maintenance Data | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| Display Data | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |

- Describe
- Algorithm
 - The technician has no parameters to input, he selects “Run” to start the calibration
 - Run Noise
 - Run Dynamic Range
 - Run Full Linearity
 - From the data received:
 - If no Low Level Interference (determined in Full Linearity)
 - Display MDS, Dynamic Range
 - Display the data in a curve with relevant areas highlighted
 - Display the data for each point in a scrollable table to one side.
 - Let the technician close the calibration or run it again.

Dynamic Range

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- *This test is part of Full Linearity, it will not be run separately*

MDS

[Top of the Document](#)

- *This test is part of Full Linearity, it will not be run separately*

Noise

[Top of the Document](#)

- Purpose
 - Measures the system blue sky noise in short pulse or long pulse

- Description
 - Park antenna
 - Run the library routine 5 times
 - Show Noise_Current, Noise_Smoothed, and each iteration's standard deviation.
- Setup

| | |
|---------------------------|---|
| Pulse Width | varies |
| Antenna | Park |
| Clutter Filter | OFF |
| Point Clutter Suppression | OFF |
| Transmitter | Not Radiating |
| Injection Point | NA |
| Matched Filter | Same as pulse width (automatic with SIGMET) |
| Receiver Protector | Normal |
| Noise Source | OFF |
| CW | OFF |
| 4 Position Switch | OFF |
| 7 Bit Test Attenuator | 103 |
| Other Procedures | |

- Describe
- Parameters/Display

| Inputs | | | |
|------------------------|--------|-------|--|
| Name | Source | Units | Description |
| Noise _{Watts} | PMD | W | The previous noise value, used in smoothing the receiver noise value |
| | | | |

| Outputs | | | |
|------------------------------|------|-------|---|
| Calibration File | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |
| Performance/Maintenance Data | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| Display Data | | | |
| Name | Type | Units | Description |
| Number | | None | Iteration number of noise data taken |
| Current Noise | | W | The noise value taken for the current iteration |
| Standard Deviation | | W | The standard deviation of the current noise value |
| Smoothed Noise | PMD | W | Current Noise smoothed with Noise value from PMD |
| Noise dBm | PMD | dBm | dBm of Smoothed Noise |

Noise Test

Short Pulse

Long Pulse

ITERATIONS
5

Parameters
Smoothing Factor R219 -- 0.33

| Number | Current Noise | Standard Deviation | Smoothed Noise | Noise dBm |
|--------|---------------|--------------------|----------------|-----------|
| text | | | | |

RUN

CANCEL

- Describe
- Algorithm
 - Park the Antenna
 - If Park fails, show alarm
 - If elevation angle $< 5^\circ$ and Not Limited Mode (i.e. non-controlling channel)
 - STOP /* can't do noise below 5 degrees */
 - Provide radio buttons for Long/Short pulse noise
 - Switch to selected pulse width if necessary
 - Provide a selection for iterations of Noise desired (input variable “n”)
 - Default is 5
 - From 1 to 99 times
 - When technician pushes start
 - For ii = 1 to n
 - Run Noise
 - Save results
 - Wait 500 milliseconds
 - Display results /* results can be displayed as the readings are taken if it's easier */

Noise Temperature

[Top of the Document](#)

- Purpose
 - Uses a calibrated Noise Source to determine the receiver Noise Temperature
 - Calibrates T_C , the antenna Noise Temperature
- Description
 - Park antenna
 - Provide radio buttons for Long/Short pulse noise
 - Switch to selected pulse width if necessary
 - Provide a selection for iterations of Noise desired (input variable “n”)
 - Default is 5
 - From 1 to 99 times
 - When technician pushes start
 - For ii = 1 to n
 - Run Noise
 - Run Noise Temperature
 - Save results
 - Wait 500 milliseconds
 - Display results /* results can be displayed as the readings are taken if it’s easier */
 - T_C Calibration
 - Have technician hook up mode adapter with 50 ohm terminator to Receiver Front End
 - Measure Noise Level
 - Record Radome temperature
 - Have technician return to normal configuration
 - Compute T_C
 - Display old and new T_C , ask for confirmation of replacement
- Setup
 - Describe
- Parameters/Display

| Inputs | | | |
|------------------------|--------|-------|--|
| Name | Source | Units | Description |
| Noise _{Watts} | PMD | W | The previous noise value, used in smoothing the receiver noise value |
| T_C | A | K | Antenna Noise Temperature |

| Outputs | | | |
|------------------------------|------|-------|-------------|
| Calibration File | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |
| Performance/Maintenance Data | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |
| Display Data | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |

- Describe
- Algorithm
 - If Controlling Channel
 - Park the Antenna
 - If Park fails
 - Show alarm
 - If elevation angle $< 5^\circ$ and Not Limited Mode (i.e. non-controlling channel)
 - STOP /* can't do noise below 5 degrees */
 - /* Now for the Fun Part */
 - Calibrating T_C
 - Measure Noise Power with all sources off and antenna parked (the usual $\text{Noise}_{\text{Current}}$, P_C in equation below)
 - Prompt the technician to hook up a 50Ω terminated mode adapter to 2A3J1.
 - Measure $\text{Noise}_{\text{Ref}}$ (P_R in equation below)
 - Save Radome temperature as $273 + \text{Radome Temp} = T_R$ /* radome temperature in Kelvin */
 - Turn on Noise Source with 5dB attenuation
 - Measure Noise_{ON}
 - Turn off Noise Source
 - Prompt technician to remove mode adapter.
 - Check Noise to see if adapter removed
 - Chide technician if mode adapter still connected, don't let him leave screen
 - Turn on Noise Source again with 5dB attenuation
 - Measure Noise Power, compare to Noise_{ON} .
 - If difference $> 0.1\text{dB}$
 - Return, don't calibrate
 - Calculate new T_C

$$T_C = \frac{T_H(P_C - P_R) - T_R(P_C - P_H)}{(P_H - P_R)}$$

| | |
|-------|--|
| T_C | Blue Sky Antenna Temperature in Kelvin measured at Receiver Front End |
| P_C | Antenna Power Level at IFD in watts |
| T_R | Dummy Load Ambient Temperature in Kelvin measured at Receiver Front End |
| P_R | Power Level at IFD with 50Ω Termination at Receiver Front End in watts |
| T_H | Temperature of Noise Source in Kelvin with 5dB attenuation at Receiver Front End |
| P_H | Power Level at IFD with Noise Source turned on and 5dB attenuation selected in watts |

- Show old T_C from adaptation data and new measured T_C
- Prompt technician to replace with new.
- Do what technician wants.
- Done.

KD

[Top of the Document](#)

- Purpose
 - Times the KD pulse for reference with Clutter Suppression, compares FE and CAB injection points. Measures the RX Prot isolation
- Description
 - Run the library routine
- Setup

- Describe
- Parameters/Display

| Inputs | | | |
|------------------------|--------|-------|--|
| Name | Source | Units | Description |
| Noise _{Watts} | PMD | W | The previous noise value, used in smoothing the receiver noise value |
| | | | |

| Outputs | | | |
|------------------------------|------|-------|--|
| Calibration File | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |
| Performance/Maintenance Data | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| Display Data | | | |
| Name | Type | Units | Description |
| KD _{range} | | m | Range of the KD Pulse in meters |
| KD _{FE} | | dBm | Power of the KD pulse through the Front End |
| KD _{cab} | | dBm | Power of the KD pulse through the Cabinet |
| KD _{suppr} | | dBm | Power of the KD pulse through the Front End with Receiver Protection ON. |

- Describe
- Algorithm
 - Show Parameters before we start
 - After the technician pushes the “RUN” button:
 - Do the KD Check per the Calibration routine
 - Display the results for the technician

Clutter Suppression

[Top of the Document](#)

- Purpose
 - Measures the Reflectivity clutter suppression of an “ideal” clutter target, the KD pulse
- Description
 - Run the library routine
- Setup
 - Describe
- Parameters/Display

| Inputs | | | |
|------------------------|--------|-------|--|
| Name | Source | Units | Description |
| Noise _{Watts} | PMD | W | The previous noise value, used in smoothing the receiver noise |

| | | | |
|--|--|--|-------|
| | | | value |
| | | | |

| Outputs | | | |
|------------------------------|------|-------|-------------|
| Calibration File | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |
| Performance/Maintenance Data | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |
| Display Data | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |

- Describe
- Algorithm
 - Describe

RFD

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- Purpose
 - Check the RF Drive Pulse for amplitude/phase
- Description
 - Generate RF Drive test pulses and measure them. We need to use a very narrow range (i.e. 25m instead of 250m) to ensure we get the center of the pulse since we can't vary the sample timing
 - Go to KD pulse mode, measure the phase of the KD pulse
- Alarms

| Alarm | Description |
|-------------------------------|--|
| Klystron Phase Shift Degraded | Phase shift more than 5 degrees from normal This alarm not in system, it's strictly a STS alarm. |

- Setup

| | |
|---------------------------|--|
| Elevation | NA (prefer higher angle but not critical) |
| Clutter Filter | OFF |
| Point Clutter Suppression | OFF |
| Interference Suppression | OFF |
| Transmitter | Radiating |
| W/G Switch | Dummy Load |
| Injection Point | Front End |
| Matched Filter | Set to Pulse Width (automatic with SIGMET) |
| Receiver Protector | Normal |
| Noise Source | OFF |
| CW | ON |

| | |
|-----------------------|----------|
| 4 Position Switch | RFD |
| 7 Bit Test Attenuator | 25 |
| Phase COHO Select | ON |
| Other Procedures | KD Check |

-
- Parameters

| Inputs | | | |
|---------------------|--------|-------|-------------|
| Name | Source | Units | Description |
| KD _{phase} | | | |
| | | | |

| Outputs | | | |
|------------------------------|------|---------|-------------------------------------|
| Calibration File | | | |
| Name | Type | Units | Description |
| RFD _{range} | | | Distance to center of RFD pulse |
| RFD _{FE} | | dBm | Peak Power measurement of RFD pulse |
| RFD _{phase} | | Degrees | Phase of RFD pulse |
| | | | |
| | | | |
| | | | |
| Performance/Maintenance Data | | | |
| Name | Type | Units | Description |
| Klystron Phase | | Degrees | Phase shift caused by Klystron |
| | | | |
| | | | |

- Algorithm
 - Turn on RFD's
 - Use Pulse Width "4" to get an RFD at range (approximately 4.5KM)
 - Do not radiate as normal since this will cause PRF Limit faults. Instead, just select RFD transmission to get just the three pulses we need to create RFD's.
 - Find Center of Pulse
 - Use 25m resolution and look for it
 - Calculate expected RFD magnitude, compare to actual
 - Yep, we'll need to add up all the path losses
 - RFD phase and jitter
 - Gather 128 points of IQ data
 - For nn=1 to 128
 - $Phase(nn) = \tan^{-1}\left(\frac{I_{nn}}{Q_{nn}}\right)$
 - $RFD_phase(nn) = Phase(nn) - Phase(nn - 1)$
 - $RFD_avg_phase = \frac{\sum_{m=1}^{128} RFD_phase(m)}{128}$
 - RFD_phase_jitter= Standard Deviation of RFD_Phase
 - KD Pulse
 - 0dB attenuation

- Go to Pulse Width “3” for the KD pulse at 25m
- Radiate for 8 seconds
- At KD_{range} , Gather 128 points of IQ data
- For $nn=1$ to 128

- $Phase(nn) = \tan^{-1}\left(\frac{I_{nn}}{Q_{nn}}\right)$

- $KD_phase(nn) = Phase(nn) - Phase(nn - 1)$

- $KD_avg_phase = \frac{\sum_{m=1}^{128} KD_phase(m)}{128}$

- KD_phase_jitter = Standard Deviation of KD_Phase
- Display
 - Phase Jitter of KD should be larger than RFD
 - Phase difference should be fixed
 - We need to quantify this
 -

CW Substitution

[Top of the Document](#)

- Purpose
 - Uses known input powers to verify receiver power measurements.
- Description
 - The technician uses a Signal Generator to inject a known power into the front end and into the cabinet.
 - We measure the power at the IFD and display expected, measured, and standard deviation for 3 parts:
 - Cabinet
 - Front End
 - Test Path
 - We display the actual error in our measurement.
 - ***Ideas /* these are NOT being implemented */***
 - **Idea 1**
 - Signal Generator hooked up, run a surveillance cut at a high angle (e.g. 45°).
 - Calculate where data should be a specific dBZ, see if it is.
 - Look at that range for entire surveillance cut to reduce problems from weather
 - **Idea 2**
 - Run a surveillance cut at a high angle (e.g. 45°) with KD pulse selected
 - Save dBZ of KD pulse for entire cut
 - Use 250m bins, not 1km bins
 - Therefore this cannot be output of DSPC
 - Compare to calculated dBZ for KD pulse
 - Display histogram of KD Pulse
- Setup
 - Short Pulse
 - Antenna Parked
- Parameters/Display

| Inputs | | | |
|--------|--------|-------|-------------|
| Name | Source | Units | Description |

| | | | |
|------------------------|-----|---|--|
| Noise _{Watts} | PMD | W | The previous noise value, used in smoothing the receiver noise value |
| | | | |

| Outputs | | | |
|------------------------------|------|-------|-------------|
| Calibration File | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |
| Performance/Maintenance Data | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |
| Display Data | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |
| | | | |

- Algorithm
 - Run the Reflectivity and Linearity calibration
 - We need Noise_{Current}, I₀ and FE_Shared
 - Have the technician hook up a calibrated CW RF signal to 4J16
 - The technician injects -40dBm into 4J16
 - Technician enters exact power injected (show exactly -40.0 as default)
 - Save Power as Test_{IN}
 - Read the Power at the IFD
 - CW_{TESTIN}
 - Have the technician hook up a calibrated CW RF Signal to 4J15
 - The technician injects -40dBm into 4J15
 - Technician enters exact power injected (show the same value as before as default)
 - Save Power as Test_{OUT}
 - Read the Power at the IFD
 - CW_{TESTOUT}
 - Have the technician remove the Signal Generator and test for removal and rehookup
 - Use a PopUp that stays on top, and must be answered before continuing
 - When the technician clicks that he's done, let's test
 - All sources off, check noise floor
 - If it's bad (at least 3dB higher or lower than Noise_{Current})
 - Reshow the window
 - Set CW to 25, inject into Front End
 - Measure Power
 - Set CW to 30, inject into Front End
 - Measure Power
 - If (difference < 3dB), then /* Not enough difference in power levels */
 - reshow the window /* we may make a new window for this */
 - We can't leave this until we're sure the Signal Generator is off the system and all the cables are reconnected
 - Now we've got the data, so let's do something with it

- Add Adaptation data for the critical path from 4J16 to FE Injection (R69+R72) to determine injected power
 - $\text{Power}_{\text{Injected}} = \text{Test}_{\text{IN}} + \text{PL_W53} + \text{PL_2A3J3} / * \text{R69} + \text{R72} */$
- Use Adaptation data to determine the expected power measured from each signal at 4J16 and 4J15
 - $\text{J15}_{\text{exp}} = \text{Test}_{\text{OUT}} + \text{CAB_Shared_Calc} + \text{PL_A36_Pad} / * \text{R78} */$
 - $\text{J16}_{\text{exp}} = \text{Test}_{\text{IN}} + \text{PL_W53} + \text{PL_2A3J3} + \text{FE_Shared_Calc}$
- Compare Measured to Expected
 - $\text{CAB}_{\text{error}} = \text{J15}_{\text{exp}} - \text{CW}_{\text{TESTOUT}}$
 - $\text{FE}_{\text{error}} = (\text{J16}_{\text{exp}} - \text{CAB}_{\text{error}}) - \text{CW}_{\text{TESTIN}}$
 - $\text{TestPath}_{\text{error}} = (\text{FE_shared} - \text{FE}_{\text{error}} - \text{Cab}_{\text{error}}) - \text{FE_Shared_Calc} / * \text{reasoning:}$
 FE_Shared contains the error for the entire path since we assume the critical path is perfect. Therefore, if we subtract what we measure for the common path with our CW Sub, what's left over is the error in the test path to 4J16 */
- Use the noise, slope, and Y-Intercept from Reflectivity and Linearity to calculate an $\text{I}_0(\text{CW_Sub})$ based on the Power read, compare to I_0

Test Attenuator

[Top of the Document](#)

Use Long Pulse to get the Noise Level and Dynamic Range advantage

- Purpose
 - This test calibrates all the steps of the test attenuator and lets the technician update Adaptation Data with the new calibration
- Description
 - We cannot get linear results from all 104 steps using just one injection point, therefore we must get data from both injection points and correlate them
 - We correct samples for noise
 - This test uses the 0dB attenuation input into the Cabinet as a reference for all other tests.
 - If 0dB attenuation into the Cabinet is above saturation (6dB), we average readings from 4dB and 8dB to set the 0dB reference
 - It then refers the 0dB Cabinet point to the 32dB Front End Point, and then to 0dB Front End.
 - The system measures the power from the Front End (FE) Path and the Cabinet (CAB) Path for every attenuation step.
 - We check to see if there's low level CW interference in our data
 - Using the references, we calculate the expected power at each attenuation for FE and CAB.
 - We determine the error between the expected and measured data at each attenuation.
 - Values above saturation and "in the noise" are not used.
 - The technician views the new calibration and decides whether to accept it into Adaptation Data.
- Setup

| | |
|---------------------------|-------------------|
| Pulse Width | Long Pulse |
| Elevation | Park |
| Clutter Filter | OFF |
| Point Clutter Suppression | OFF |
| Transmitter | Not Radiating |
| Injection Point | Front End/Cabinet |
| Matched Filter | Long Pulse |
| Receiver Protector | Normal |
| Noise Source | OFF |
| CW | ON |
| 4 Position Switch | CW |
| 7 Bit Test Attenuator | varies |
| Other Procedures | Noise |

- Parameters/Display

| Inputs | | | |
|------------------------|--------|-------|--|
| Name | Source | Units | Description |
| Noise _{Watts} | PMD | W | The previous noise value, used in smoothing the receiver noise value |
| FE_Measure(ii) | | dBm | Measured values of CW power at ii attenuation |
| CAB_Measure(ii) | | dBm | Measured values of CW power at ii attenuation |
| FE_exp(ii) | | dBm | Expected CW power at ii attenuation |
| CAB_exp(ii) | | dBm | Expected CW power at ii attenuation |
| FE_Noise_exp(ii) | | dBm | Noise corrected expected CW power at ii attenuation |
| CAB_Noise_exp(ii) | | dBm | Noise corrected expected CW power at ii attenuation |
| CAB _{ref} | | dBm | Cabinet reference for determining expected values |
| FE _{ref} | | dBm | Front End reference for determining expected values |
| FE_Delta_Raw(ii) | | dB | Difference between expected and measured for Front End at attenuation ii |
| CAB_Delta_Raw(ii) | | dB | Difference between expected and measured for Cabinet at attenuation ii |
| FE_Delta_Noise(ii) | | dB | Difference between noise corrected expected and measured for Front End at attenuation ii |
| CAB_Delta_Noise(ii) | | dB | Difference between noise corrected expected and measured for Cabinet at attenuation ii |
| Delta(ii) | | dBm | Best Delta used to correct attenuation at ii |
| NewCal(ii) | | dBm | The new resulting attenuation at ii |

| Outputs | | | |
|------------------------------|------|-------|---|
| Calibration File | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |
| Performance/Maintenance Data | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| Display Data | | | |
| Name | Type | Units | Description |
| Attenuation | | | The attenuation for calibration results |
| Adaptation | | dBm | The value currently in adaptation data for the specific attenuation |
| NewCal | | dBm | The new calibrated Value |
| Delta | | dB | The delta from “perfect” |

- Algorithm
 - Switch to Setup parameters
 - Run the Noise procedure to get a current noise reading
 - For Front End**
 - Switch to FE Injection
 - For ii = 0 to 103
 - Switch to atten of ii
 - FE_Measure(ii)= $10\log_{10}(I_{Q_{power}})$ /* Power in dBm */
 - For Cabinet**

- Switch to CAB Injection
- For ii = 0 to 103
 - Switch to atten of ii
 - $CAB_Measure(ii) = 10 \log_{10}(I_{Q_{power}})$ /* Power in dBm */
-
- If $CAB_Measure(0) > 6dB$
 - $CAB_{ref} = Avg(CAB_Measure(4) - 4, CAB_Measure(8) - 8)$
- Else
 - $CAB_{ref} = CAB_Measure(0)$ /* This is our reference for all measurements */
- $FE_{ref} = FE_Measure(32) + (CAB_Measure(0) - CAB_Measure(32))$ /* this is our front end reference */
- /* Now we have the measured data in dBm */
- /* With both curves, we should cover the entire 104 steps of the attenuator from 0 to 103 with data we can use */
- /* Now calculate the expected values for both arrays
 - Use Noise value to determine expected values so we get more accurate results at low input powers
 - Need to convert dB values to watts to add noise, then convert back */
- For Front End
 - For ii = 0 to 103
 - $FE_{Exp}(ii) = FE_{ref} - ii$
 - $FE_{NoiseExp}(ii) = 10 \log_{10} \left(10^{\frac{(FE_{Exp}(ii))}{10}} + Noise_{current} \right)$
 - $FE_{\Delta raw}(ii) = FE_{Exp}(ii) - FE_{meas}(ii)$
 - $FE_{\Delta noise}(ii) = FE_{NoiseExp}(ii) - FE_{meas}(ii)$
- For Cabinet
 - For ii = 0 to 103
 - $CAB_{exp}(ii) = CAB_{ref} - ii$
 - $CAB_{NoiseExp}(ii) = 10 \log_{10} \left(10^{\frac{(CAB_{exp}(ii))}{10}} + Noise_{current} \right)$
 - $CAB_{\Delta raw}(ii) = CAB_{Exp}(ii) - CAB_{meas}(ii)$
 - $CAB_{\Delta noise}(ii) = CAB_{NoiseExp}(ii) - CAB_{meas}(ii)$
 -
- /* Now that we have the expected and measured data and deltas, we can calculate each attenuation's correction factor. */
- ***I still need to decide what to do if we have interference problems! But this should work for a start.***
- From ii = 0 to 103 /* At each data point we check to see if the signal is too far below noise to use, and then check to see which measurement is closer, and that's the one we use */
 - IF $CAB_{\Delta raw}(ii) < -6$
 - IF $FE_{\Delta raw}(ii) < -6$
 - $\Delta(ii) = 0$
 - Else
 - $\Delta(ii) = FE_{\Delta noise}(ii)$
 - Else
 - IF $|CAB_{\Delta noise}(ii)| > |FE_{\Delta noise}(ii)|$
 - $\Delta(ii) = FE_{\Delta noise}(ii)$
 - Else
 - $\Delta(ii) = CAB_{\Delta noise}(ii)$
 - $Result(ii) = -(ii + \Delta(ii))$
 -

- Display Data, highlighting any delta greater than 1dB
- If any $|\Delta(ii)| > 1.5$
 - Don't allow update to adaptation data
- Else
 - Give option to update adaptation data

Velocity/Spectrum Width Processing

[Top of the Document](#)

- Purpose
 - Inputs known I and Q samples to measure V and W throughout the Nyquist Interval. Verifies proper operation of RVP.
- Description
 - Run library routine for V/SW Processing
 - Display V and W expected and measured for every different V and W in the file
 - Highlight if any values do not match.
- Setup
 - Describe
- Parameters/Display

| Inputs | | | |
|------------------------|--------|-------|--|
| Name | Source | Units | Description |
| Noise _{Watts} | PMD | W | The previous noise value, used in smoothing the receiver noise value |
| | | | |

| Outputs | | | |
|------------------------------|------|-------|-------------|
| Calibration File | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |
| Performance/Maintenance Data | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| Display Data | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |

- Describe
- Algorithm
 - Describe

Velocity/Spectrum Width

[Top of the Document](#)

- Purpose
 - Measures the receiver system capability to measure V and W at 4 selected Nyquist intervals.
- Description
 - Run Library routine for V/SW
 - Display V and W expected and measured for each V and W input
 - Highlight any values out of range
- Setup
 - Describe
- Parameters/Display

| Inputs | | | |
|------------------------|--------|-------|--|
| Name | Source | Units | Description |
| Noise _{Watts} | PMD | W | The previous noise value, used in smoothing the receiver noise value |
| | | | |

| Outputs | | | |
|------------------------------|------|-------|-------------|
| Calibration File | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |
| Performance/Maintenance Data | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |
| Display Data | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |

- Describe
- Algorithm
 - Have a Start/Run button for the technician
 - Radiate transmitter for 8 second warmup
 - Message on screen saying “Transmitter Warmup”
 - Run V/SW routine
 - Show results of each V and W
 - Show any alarms resulting from results

Transmitter Power

[Top of the Document](#)

- Purpose
 - Calibrates the Power Monitor to match known transmitter power output
- Description
 - The technician verifies that they have calibrated the transmitter power (perhaps inputs the measured peak transmitter power)
 - Radiate transmitter for 8 second warmup
 - Measure transmitter power for 30 seconds, once per second

- Throw out high and low readings
- Average all readings
- Correct for path to transmitter
- Correct for duty cycle
- Compare to calibrated peak power
- Use ratio to correct TR9
- Setup
 - Describe
- Parameters/Display

| Inputs | | | |
|--------|--------|-------|-------------|
| Name | Source | Units | Description |
| | | | |
| | | | |

| Outputs | | | |
|------------------------------|------|-------|------------------------|
| Calibration File | | | |
| Name | Type | Units | Description |
| | | KW | Transmitter Peak Power |
| | | | |
| | | | |
| Performance/Maintenance Data | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| Display Data | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| | | | |

- Describe
- Algorithm
 - Display current Power Monitor Reading in bits, update every second
 - Ask technician to input calibrated peak power output of transmitter from EHB 6-511 measurement
 - $P_{wr_{meas}}$
 - Park Antenna, select Dummy Load
 - Do a Power Meter Zero routine and display if out of bounds
 - Radiate in short pulse, 1000hz
 - Radiate for 8 seconds warmup
 - For 30 seconds, record the average transmitter power every second
 - Throw out the maximum and minimum readings
 - Average the power meter readings
 - Convert reading to dBm
 - Subtract path losses from TR17 to R51 to get average power at the klystron (TR17, TR18, TR19, TR20, TR21, TR23, TR32, R48, R49, R51) /* assuming power meter readings were mW at the power meter, not corrected for this path already */
 - Calculate Duty Cycle in dB
 - $DC = 10 \log(PRF * PW)$, $PRF = 1000$, and $PW = TR5$

- $Tx_{peak} = \frac{10^{(Tx_{ave}-DC)/10}}{10^6}$ /* Peak power in kW */
- $TR9_{new} = TR9 * \left(\frac{Pwr_{meas}}{Tx_{peak}} \right)$
- Show Pwr_{meas} , Tx_{peak} , $TR9$, $TR9_{new}$
- Ask if technician accepts new reading
- If yes
 - Update adaptation data with $TR9_{new}$
- Else
 - Clear everything, start over

Log Amp Detector for RF Test

[Top of the Document](#)

- Purpose
 - Calibrates 4A29 Log Amp Detector for RF testing (RIOS)
- Description
 - This procedure checks the transfer curve of the 4A29, and also corrects for bias.
 - Input at -5 and -35dBm into the 4A29 using BITE (CW), and calculate the curve (Least Squares Linear Curve Fit).
 - Compare Long and Short pulse through the transmitter, ensure they're the same.
 - Calibrate the IF injected test power at 0dBm.
 - Show all the test points throughout and their expected vs measured levels
 - Allow adaptation data to be updated for 4A29
- Setup

| | |
|----------------------------|---------------------------|
| Pulse Width | NA |
| Elevation | Park |
| Clutter Filter | NA |
| Point Clutter Suppression | NA |
| Transmitter | Not Radiating |
| Waveguide | Dummy Load |
| Injection Point | Front End/Cabinet |
| Matched Filter | NA |
| Receiver Protector | Normal |
| Noise Source | OFF |
| CW | ON |
| 4 Position Switch | CW |
| 7 Bit Test Attenuator | varies |
| 10 Position RF Test Switch | Position 7, Attenuated RF |
| Other Procedures | None |

- Parameters/Display

| Inputs | | | |
|-----------|--------|-------|-------------|
| Name | Source | Units | Description |
| Slope | A | | |
| Intercept | A | | |

| Outputs |
|------------------|
| Calibration File |

| Name | Type | Units | Description |
|-------------------------------------|------|-------|-------------|
| | | | |
| | | | |
| | | | |
| Performance/Maintenance Data | | | |
| Name | Type | Units | Description |
| | | | |
| | | | |
| Display Data | | | |
| Name | Type | Units | Description |
| Slope Adapt | | | |
| Intercept Adapt | | | |
| Slope Measured | | | |
| Intercept Measured | | | |

- Describe
- Algorithm
 - MACROS
 - Obtain A/D Converter measurements
 - Take 10 independent samples
 - Throw out the 2 maximum and the 2 minimum readings
 - Average the remaining 6
 - Convert sample to voltage

$$V = \frac{(Max - Min)}{32768} \times 17.7$$
 -
 - Convert sample voltage to dBm and back again

$$V = \frac{P - Offset}{Slope}$$
 -
 - $P = V \times Slope + Offset$
 - Power_{in}= R34+R59+R65+R107 (Position 7 on 10 Position RF Test Switch, Attenuated RF Input, using CW with 0dB attenuation) /* should be around -6dBm */
 - Have technician measure and input exact value for Power_{in}
 - Display value expected from adaptation data as default.
 - Save input value as Power_{in}
 - IF Power_{in}>0 or Power_{in}<-12
 - Can't run this
 - Post unexpected error message, and tell them why
 - Power outside bounds (0 to -12dBm).
 - Turn CW Off
 - Get sample from A/D Converter, save least value as MIN
 - For ii=0 to 5
 - Set 7 bit test attenuator to ii
 - Get sample from A/D converter, record MAX
 - Convert sample to volts
 - Set V_{samp}(V,(ii+Power_{in}))
 - For ii=23 to 28
 - Set 7 bit test attenuator to ii
 - Get sample from A/D converter
 - Convert sample to volts
 - Set V_{samp}(V,(ii+Power_{in}))
 - Do least squares linear curve fit on data, with (ii+Power_{in}) as “y” values and V as “x” values

- Slope and intercept are called scale and bias
 - $Scale = Slope$
 - $Bias = Intercept$
- Display current scale and bias with measured scale and bias
- Ask if new data is accepted
- If yes
 - put measured slope and intercept into Adaptation Data
- else
 - don't
 - clear measured values, go back to start

[Top of the Document](#)